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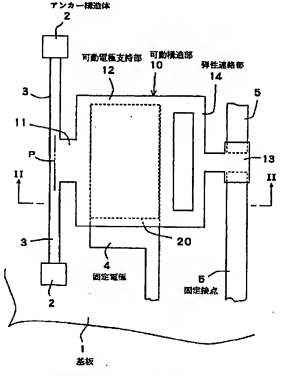
(54)【発明の名称】　静電リレー

(57)【要約】
【課題】　低電圧駆動、低接点抵抗、高接点容量の実用性の高い静電リレーを提供する。
【解決手段】　基板１上に空隙を持って保持された両持ち梁状のねじれ弾性部３と、該ねじれ弾性部３による弾性支持によって回動自在な可動構造部１０と、該可動構造部１０の少なくとも一方の端部に配置された少なくとも１個の可動接点と、前記可動構造部１０の回動支点Ｐと前記可動接点間に配置された可動電極２０と、前記可動接点に接触可能に対向する前記基板上に形成された少なくとも１個の固定接点５と、前記可動電極２０に対向する如く前記基板上に形成された固定電極４とを備えており、さらに前記可動構造部１０の回動支点Ｐと前記可動接点間の少なくとも一部が弾性連絡部１４となっている。



３：ねじれ弾性部、１８：可動接点支持部

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【特許請求の範囲】

【請求項１】　基板と、該基板上に空隙を持って保持された両持ち梁状のねじれ弾性部と、該ねじれ弾性部による弾性支持によって回動自在な可動構造部と、該可動構造部の少なくとも一方の端部に配置された少なくとも１個の可動接点と、前記可動構造部の回動支点と前記可動接点間に配置された可動電極と、前記可動接点に接触可能に対向する前記基板上に形成された少なくとも１個の固定接点と、前記可動電極に対向する如く前記基板上に形成された固定電極とを備えた静電リレーにおいて、前記可動構造部の回動支点と前記可動接点間の少なくとも一部が弾性連絡部となっていることを特徴とする静電リレー。

【請求項２】　前記弾性連絡部が、前記可動構造部における前記可動電極と前記可動接点間にあり、前記可動電極と前記固定電極間への電圧印加時に、弾性変形により前記可動接点と前記固定接点とを平行状態で接触可能に構成した請求項１記載の静電リレー。

【請求項３】　前記弾性連絡部が、前記可動構造部における前記回動支点と前記可動電極間にあり、前記可動電極と前記固定電極間への電圧印加時に、弾性変形により前記可動電極が前記固定電極に対して平行乃至平行に近い近接状態に吸引されるように構成した請求項１又は２記載の静電リレー。

【請求項４】　前記可動電極と前記固定電極間に誘電体層が介在している請求項１，２又は３記載の静電リレー。

【請求項５】　前記可動構造部が前記両持ち梁状のねじれ弾性部の両側に延長しており、前記回動支点に対して少なくとも一方の側に前記可動接点が、両側に前記可動電極がそれぞれ配置されるとともに、両側の前記可動電極にそれぞれ対向する如く前記基板上に前記固定電極が形成されている請求項１，２，３又は４記載の静電リレー。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、静電引力を利用する静電アクチュエーターを、駆動源として用いた静電リレーに関する。

【０００２】

【従来の技術】静電リレーは、従来の電磁石を利用した電磁式リレーと異なり、静電引力を駆動力として接点の開閉を行うリレーであり、電磁力を発生するためのコイルが不要で機械部品が少なく、小型化が可能であること、及び本質的にコンデンサーである静電アクチュエーターを駆動源として用いるため、低消費電力であるという特徴があり、実用化に向けて研究が進められている。

【０００３】このような、静電リレーとしては、例えば特開平２－１００２２４号公報にあるように、単結晶Ｓｉを選択エッチングによりトーションバー弾性体とそれに接続されたシーソー状構造体とを形成し、その構造体に静電アクチュエーターの可動電極部とリレーの可動接点とを形成して、それぞれに対向する位置に固定電極と固定接点とを設けた電気絶縁性基板上にスペーサーを介して配置したものがある。

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【０００４】この静電リレーは、動作時に固定電極と可動電極間に電圧を印加することにより、トーションバー弾性体のねじれによって、電圧が印加された側のシーソー状構造体が回転運動を行い可動接点を固定接点に接触させるものである。

【０００５】

【発明が解決しようとする課題】この静電リレーでは、可動接点が、シーソー状構造体の端部に設けられているため、接触時に、可動接点が固定接点に対し傾斜状態で接触するため十分な接触面積が得られず、接点抵抗が高くなる。また、可動接点を設ける構造体の位置を適切に選ばないと構造体が可動接点と同時に接触してしまうため、接点間の圧力が不十分になる可能性がある。

【０００６】さらに、このような構成の静電リレーは、固定電極に対向する可動電極が、トーションバー弾性体により空隙を介して保持されたシーソー状構造体の可動接点位置よりも回動支点寄りに形成されるため、可動接点が固定接点に接触し、シーソー状構造体の回転運動が停止した時点で、固定電極と可動電極との間に楔状のエアギャップが生じる。

【０００７】ところが静電引力は電極間隔の逆自乗に比例する。従って、静電アクチュエーターは吸引動作時でもこのエアギャップのため静電引力が小さくなってしまう。このため接点に十分な圧力がかからないので接点抵抗を十分小さくすることができず、またこれを克服するために動作電圧を高くすることは静電リレーの実用性を著しく妨げることになる。

【０００８】本発明は、上記の点に鑑み、低電圧駆動、低接点抵抗、高接点容量の実用性の高い静電リレーを提供することを目的とする。

【０００９】本発明のその他の目的や新規な特徴は後述の実施の形態において明らかにする。

【００１０】

【課題を解決するための手段】上記目的を達成するために、本発明の静電リレーは、基板と、該基板上に空隙を持って保持された両持ち梁状のねじれ弾性部と、該ねじれ弾性部による弾性支持によって回動自在な可動構造部と、該可動構造部の少なくとも一方の端部に配置された少なくとも１個の可動接点と、前記可動構造部の回動支点と前記可動接点間に配置された可動電極と、前記可動接点に接触可能に対向する前記基板上に形成された少なくとも１個の固定接点と、前記可動電極に対向する如く前記基板上に形成された固定電極とを備えた構成において、前記可動構造部の回動支点と前記可動接点間の少なくとも一部が弾性連絡部となっていることを特徴として

いる。

【００１１】また、前記静電リレーにおいて、前記弾性連絡部が、前記可動構造部における前記可動電極と前記可動接点間にあり、前記可動電極と前記固定電極間への電圧印加時に、弾性変形により前記可動接点と前記固定接点とを平行状態で接触可能に構成するとよい。

【００１２】さらに、前記弾性連絡部が、前記可動構造部における前記回動支点と前記可動電極間にあり、前記可動電極と前記固定電極間への電圧印加時に、弾性変形により前記可動電極が前記固定電極に対して平行乃至平行に近い近接状態に吸引されるように構成するとよい。

【００１３】なお、前記可動電極と前記固定電極間に誘電体層が介在していてもよい。

【００１４】また、前記可動構造部が前記両持ち梁状のねじれ弾性部の両側に延長しており、前記回動支点に対して少なくとも一方の側に前記可動接点が、両側に前記可動電極がそれぞれ配置されるとともに、両側の前記可動電極にそれぞれ対向する如く前記基板上に前記固定電極が形成された構成としてもよい。

【００１５】

【発明の実施の形態】以下、本発明に係る静電リレーの実施の形態を図面に従って説明する。

【００１６】図１乃至図４は本発明に係る静電リレーの第１の実施の形態を示す。これらの図において、静電リレーは、絶縁性基板１と、基板１上に立設、固定されたアンカー構造体２と、アンカー構造体２で基板１から空隙を持って保持された両持ち梁状のねじれ弾性部３と、ねじれ弾性部３による弾性支持によって回動自在なリレー構造体をなす可動構造部１０とを具備している。前記絶縁性基板１は少なくとも表面が絶縁処理されているもので、例えば表面にＳｉＯ$_2$絶縁層を設けた単結晶Ｓｉ基板等である。アンカー構造体２、両持ち梁状のねじれ弾性部３、可動構造部１０の３者は多結晶Ｓｉ等により一体に形成されている。

【００１７】リレー構造体を構成する可動構造部１０は、前記両持ち梁状のねじれ弾性部３に接続する両持ち梁接続部１１、可動電極支持部１２、可動接点支持部１３、及び可動電極支持部１２と可動接点支持部１３とを接続する弾性連絡部１４から構成されており、弾性連絡部１４は両持ち梁状に形成され、そのねじれにより可動接点支持部１３が回転動作可能になっている。

【００１８】リレー構造体としての可動構造部１０の基板対向面側には、図２乃至図４の如くそれぞれ可動電極２０及びこの表面を被覆した絶縁層（誘電体層）２１、可動接点２２が形成、配置され、これらに対向する基板上に固定電極４及び固定接点５が形成、配置されている。絶縁性基板１上に固定された固定電極４と可動電極支持部１２に固定された可動電極２０とは両者間に印加された電圧により静電引力を発生する静電アクチュエーターを構成する部分であり、固定電極４と可動電極２０とは図示しない配線により外部電源に接続される。

【００１９】次に、第１の実施の形態で示した静電リレーの動作原理を説明する。図２は非動作状態（電圧を印加しない状態）での各電極及び各接点の位置を示し、接点５，２２間は開いている。静電アクチュエーターを構成する固定電極４と可動電極２０間に電圧を印加すれば、両電極間には静電引力が発生し、図３のようにリレー構造体としての可動構造部１０は、両持ち梁状のねじれ弾性部３のねじれ弾性変形により可動接点２２が固定接点５に接触するまで、基板側に回転運動する。この回動支点は図１の線Ｐの位置である。

【００２０】従来の静電リレーでは、この時点でリレー構造体の動作が停止する。このとき図３から明らかなように可動接点２２と固定接点５は点接触状態であり、十分な接触面積が得られず、接点抵抗が高くなってしまう。また、接触点が小さく、抵抗が高いため、通過電流が集中して接点温度上昇を招き、接点の溶着等の故障を発生しやすくなる。更にまた静電アクチュエーターの固定電極４と可動電極２０の間隔が広いため十分な静電引力を発生することができず、接点圧力が十分とれない。このことは接点抵抗の上昇を招く。接点圧力を上げるためには更に高い電圧を印加せねばならず、静電リレーの動作電圧が高くなって実用性に欠けてしまう。

【００２１】しかしながら、本実施の形態の静電リレーでは、更にこの時点から、静電アクチュエーターの吸引力により弾性連絡部１４が変形され、ついには図４に示すように可動接点２２が固定接点５に対し平行になるように変形する。図４から明らかなように、この時で接点５，２２は平行状態で面接触し、図１のように一対の固定接点５が可動接点２２で短絡され十分低い接点抵抗と十分大きな接点電流容量を得ることができる。更に、静電アクチュエーターの電極４，２０間の距離は図３の状態と比較して著しく近接させることができる。つまり、静電アクチュエーターの静電引力は電極間隔の自乗に逆比例するため、動作電圧が低くとも接点に十分な圧力を加えることができ、低い接点抵抗と低動作電圧という従来の静電リレーでは困難であった特性が達成できる。

【００２２】なお、電極４，２０間の電圧を零にすれば、弾性部３のねじれ弾性変形が元の状態に戻り、可動構造部１０は図２の非動作状態に復帰する。

【００２３】この第１の実施の形態によれば、次の通りの効果を得ることができる。

【００２４】(1)　弾性連絡部１４が、リレー構造体を構成する可動構造部１０における可動電極２０と可動接点２２間に位置し、固定電極４と可動電極２０間への電圧印加時に、ねじれ弾性変形により固定接点５と可動接点２２とを平行状態で接触可能に構成したので、接点５，２２を面接触させて、十分低い接点抵抗と十分大きな接点電流容量を得ることができる。

【００２５】(2)　静電アクチュエーターの電極４，２

０間の距離は従来構造の場合の限界であった図３の状態と比較して著しく近接させることができ、静電引力を大きくして動作電圧が低くとも接点に十分な圧力を加えることができ、低動作電圧で作動可能な静電リレーを実現できる。

【００２６】(3)　可動電極２０を絶縁層２１で覆っており、電極４，２０が直接接触する短絡事故を確実に防止できる。なお、可動電極２０と固定電極４間に絶縁層２１が介在しても、絶縁層２１は空気に比べて誘電率の高い誘電体であり、絶縁層２１の存在による静電引力の低下は考えなくてよい（無視できる。）。

【００２７】なお、第１の実施の形態では、弾性連絡部１４として、両持ち梁のねじれ弾性を用いる構造を示したが、弾性連絡部の構成は、これに限るものではなく、静電リレー動作電圧印加時に弾性変形により前記可動接点と前記固定接点を平行に接触させ得るように配置され、前記固定電極と可動電極間に発生する静電引力にて前記両接点が平行に接触するに至る変形が可能な弾性率を持てばよく、例えば可動電極支持部１２から引き出された片持ち梁形状等をとっても同様の効果が得られる。

【００２８】図５乃至図８は本発明の第２の実施の形態を示す。これらの図において、リレー構造体を構成する可動構造部３０は、絶縁性基板１からアンカー構造体２を介して両持ち梁状のねじれ弾性部３によって基板１から空隙を持って保持される。可動構造部３０は、可動電極支持部３２、可動接点支持部３３、及び両持ち梁状のねじれ弾性部３と可動電極支持部３２とを所定の長さで接続する弾性連絡部３４から構成されており、弾性連絡部３4は、可動電極支持部３２より細く複数の帯状に形成され、上下面に垂直な方向への弾性変形（撓みによる変形）により可動電極支持部３２と可動接点支持部３３が変移可能になっている。

【００２９】リレー構造体としての可動構造部３０の基板対向面側には、図６乃至図８の如くそれぞれ可動電極２０及び可動接点２２が形成、配置され、これらに対向する基板上に固定電極４及びこの表面を被覆した絶縁層（誘電体層）６、固定接点５が形成、配置されている。絶縁性基板１上に固定された固定電極４と可動電極支持部３２に固定された可動電極２０とは両者間に印加された電圧により静電引力を発生する静電アクチュエーターを構成する部分である。

【００３０】なお、その他の構成は前述した第１の実施の形態と同様である。

【００３１】次に、第２の実施の形態で示した静電リレーの動作原理を説明する。図６は非動作状態（電圧を印加しない状態）での各電極及び各接点の位置を示し、接点５，２２間は開いている。静電アクチュエーターを構成する固定電極４と可動電極２０間に電圧を印加すれば、両電極間には静電引力が発生し、図７のようにリレー構造体としての可動構造部３０は、両持ち梁状のねじれ弾性部３のねじれ弾性により可動接点２２が固定接点５に接触するまで、基板側に回転運動する。

【００３２】従来の静電リレーでは、この時点でリレー構造体の動作が停止するため、第１の実施の形態の動作説明にて述べた如く、接点接触面積の不足、接点圧力の不足、高い動作電圧等の問題点が生じる。

【００３３】しかしながら、本実施の形態の静電リレーでは、更にこの時点から、静電アクチュエーターの吸引力により所定の長さを持つ弾性連絡部３４が撓んで変形され、ついには図８に示すように、可動電極２０と固定電極４とが平行乃至平行に近い状態になり、更に可動接点２２と固定接点５も平行状態になるように変形する。図８から明らかなように、この時接点５，２２は平行状態で面接触し、十分低い接点抵抗と大きな接点電流容量を得ることができる。更に、静電アクチュエーターの電極４，２０間の距離は図７の状態と比較して、絶縁層６を介してほぼ接触に至るまで近接させることができ、極めて強い静電引力を発生することができる。従って、低い動作電圧でも接点に十分な圧力を加えることができ、低い接点抵抗と低動作電圧という従来の静電リレーでは困難であった特性が容易に達成できる。

【００３４】このように、第２の実施の形態によれば、撓み変形可能な所定長の弾性連絡部３４が、リレー構造体をなす可動構造部３０における回動支点Ｐ（両持ち梁状のねじれ弾性部３のねじれ中心）と可動電極２０間に位置しており、固定電極４と可動電極２０間への電圧印加時に、弾性変形により可動電極２０が固定電極４に対して平行乃至平行に近い近接状態に吸引されるように構成でき、静電引力を大きくできるとともに、接点５，２２を面接触させて、十分低い接点抵抗と十分大きな接点電流容量を得ることを可能とし、さらには低動作電圧の静電リレーを実現できる。

【００３５】なお、第２の実施の形態では、弾性連絡部３４として、可動構造部３０の細く形成された所定長部分の基板に対する垂直方向への弾性変形を用いる構造を示したが、弾性連絡部の構成は、これに限るものではなく、静電リレー動作電圧印加時に弾性変形により可動電極と固定電極とが平行になり得るように配置され、前記固定電極と可動電極間に発生する静電引力にて両電極が平行乃至平行に近い状態に至る変形が可能な弾性率を持てばよく、例えば図１で示した弾性連絡部１４のような、両持ち梁のねじれ回転を用いても同様の効果が得られる。

【００３６】図９乃至図１１は本発明の第３の実施の形態であり、弾性連絡部が、リレー構造体を構成する可動構造部における可動電極と可動接点間に設けられているとともに、可動構造部の回動支点（両持ち梁状のねじれ弾性部のねじれ中心）と可動電極間にも設けられている場合を示す。これらの図において、リレー構造体を構成する可動構造部４０は、絶縁性基板１からアンカー構造

体２を介して両持ち梁状のねじれ弾性部３によって基板１から空隙を持って保持される。可動構造部４０は、所定長の両持ち梁接続部４１、可動電極支持部４２、可動接点支持部４３、両持ち梁接続部４１の先端部と可動電極支持部４２とを接続する第１の弾性連絡部４４、及び可動電極支持部４２と可動接点支持部４３とを接続する第２の弾性連絡部４５から構成されている。第１及び第２の弾性連絡部４４，４５は、両持ち梁状のねじれ弾性部であり、両持ち梁接続部４１の先端側に対して可動電極支持部４２が第１の弾性連絡部４４により回動自在に、可動電極支持部４２の先端側に対して可動接点支持部４３が第２の弾性連絡部４５により回動自在にそれぞれ支持されている。

【００３７】なお、その他の構成は前述した第１の実施の形態と同様であり、同一又は相当部分に同一符号を付して説明を省略する。

【００３８】図１０及び図１１に第３の実施の形態に係る静電リレーの動作状況を示す。図１０は非動作状態（電圧を印加しない状態）での各電極及び各接点の位置を示す。静電アクチュエーターを構成する固定電極４と可動電極２０間に電圧を印加すれば、両電極間には静電引力が発生し、図１１のようにリレー構造体としての可動構造部４０は、両持ち梁状のねじれ弾性部３のねじれ弾性変形により可動接点２２を固定接点５に接触させ、さらに第１及び第２の弾性連絡部４４，４５のねじれ弾性変形により可動接点２２と固定接点５を平行に密着させた状態に至るまで、基板側に回転運動する。

【００３９】この図１１から明らかなように、この第３の実施の形態を取った場合、ねじれ弾性部である第１及び第２の弾性連絡部４４，４５の弾性率を適切に選ぶことにより、可動接点２２と固定接点５とを平行に密着させた上で、静電アクチュエーターの可動電極２０と固定電極４をほぼ平行に保ちながら、かつエアギャップを持って対向させることが可能になる。このことは、例えば、図３に示したような楔形エアギャップを持った場合より更に強い静電引力を得ることができると同時に、可動電極２０と固定電極４の接触を完全に避けることが可能になる。従って、静電アクチュエーターを構成するための可動電極２０又は固定電極４上に形成される絶縁層が不要、もしくは絶縁耐圧を低くすることができるとともに、アクチュエーター電極間の不用意な接触による固着等の問題を避けることが可能となる。

【００４０】図１２及び図１３は本発明の第４の実施の形態であり、リレー構造体を、基板から該リレー構造体を回転支持する両持ち梁状のねじれ弾性部の両側に延長し、該両持ち梁状のねじれ弾性部に対して対称形状に配置した例を示す。すなわち、第４の実施の形態に係る静電リレーは、絶縁性基板１と、基板１上に立設、固定されたアンカー構造体２と、アンカー構造体２で基板１から空隙を持って保持された両持ち梁状のねじれ弾性部３と、ねじれ弾性部３による弾性支持によって回動自在なように両側に対称配置されたリレー構造体をなす可動構造部１０Ａ，１０Ｂとを具備している。各可動構造部１０Ａ，１０Ｂの電極及び接点構成等は、前述した第１の実施の形態と同様であるので、同一又は相当部分に同一符号を付して詳細は省略する。

【００４１】この第４の実施の形態の構成を取れば、静電リレー動作時に左右の静電アクチュエーターの電極４，２０間に図１４に示すような反転出力電圧を与えることにより、一方のリレー接点５，２２のオフ（ＯＦＦ）動作時に、当該接点の引き離し作用が両持ち梁状のねじれ弾性部３の弾性による復帰運動のみによらず、反対側静電アクチュエーターの静電引力を用いることが可能になり、確実なリレー接点のオフ動作が可能になる。

【００４２】また、この時、左右の固定接点の一方の極を図１２に図示の如く共通に接続すれば、図１５に示すように切り替えスイッチを容易に構成することが可能である。

【００４３】さらに、可動構造部１０Ａ，１０Ｂのいずれか一方の可動接点２２及びこれに対向する基板側の固定接点５の組を省略して、オフ動作の確実性を向上させた構成とすることもできる。

【００４４】なお、今まで説明した各実施の形態では静電アクチュエーターの一方の電極となる可動電極をリレー構造体（可動構造部）の基板面側に形成した例を示したが、同電極位置はこれに限らず、実質的に固定電極と可動電極間に静電引力を発生させ得ればよく、例えば静電アクチュエーターの構造体、つまりリレー構造体が高誘電率の絶縁体や高抵抗体であれば、可動電極位置をリレー構造体の基板面側の反対面に配置してもよく、また、前記構造体自体を導電性部材で構成すれば、当該構造体自体を可動電極とすることも可能である。

【００４５】また、リレー構造体（可動構造部）の端部に配置される可動接点２２は１個に限らず、複数個配置される場合もある。

【００４６】

【実施例】次に本発明を実施例により具体的に説明する。

【００４７】図１６及び図１７は本実施例で形成した静電リレーの平面図及び側面図である。本実施例では、まず、図１８（Ａ）のように熱酸化法により厚さ約１μｍのＳｉＯ$_2$絶縁層５１ａを形成した単結晶Ｓｉ板５１を基板とし、厚さ５００ｎｍ程度のＡｕをスパッタ法により基板全面に形成し、次にフォトエッチングを用い、静電アクチュエーターの固定電極５４とリレーの固定接点５５をそれぞれパターニングした。次に反応性スパッタ法により、基板全面に約１００ｎｍのＳｉＮ絶縁層を形成し、同じくフォトエッチング法により静電アクチュエーターの固定電極５４上を残して同絶縁層を選択除去し、絶縁層５６とした。

【００４８】次に、図１８（Ｂ）のように減圧ＣＶＤ法を用い、基板全面に犠牲層８１となるＳｉＯ₂膜を約３μｍ程度堆積した。それから可動接点７２に相当する位置のＳｉＯ₂膜をＲＩＥ法により約５００ｎｍ掘り下げ、更に基板全面に約５００ｎｍのＡｕ膜を約２０ｎｍのＳｉＮ反応防止層とともに形成し、所定の形状にフォトエッチングでパターニングして静電アクチュエーターの可動電極７０及びリレーの可動接点７２を形成した。さらにこの後、犠牲層８１のＳｉＯ₂膜のアンカー構造体５２に相当する部分８２をフォトエッチングを用いて選択除去する。

【００４９】最後に減圧ＣＶＤ法を用い、図１８（Ｃ）のように基板全面に多結晶Ｓｉ膜８３を約４μｍ形成し、以下に述べるリレー構造体となる可動構造部の形状にＲＩＥ法によりパターニングした。

【００５０】この後、犠牲層８１のＳｉＯ₂膜をＨＦにより選択エッチングし、図１６及び図１７に示したリレー構造体となる可動構造部６０をリリースして形成した。

【００５１】両持ち梁状のねじれ弾性部５３はアンカー構造体５２からの長さａが約１００μｍ、幅約６μｍ程度である。また、リレー構造体を構成する可動構造部６０は、長さｂが約１００μｍの両持ち梁接続部６１、幅ｃ及び長さｄがそれぞれ約２００μｍの可動電極支持部６２、幅約６μｍ、長さｅが約５０μｍの両持ち梁状のねじれ弾性連絡部６４、及び長さｆが約５０μｍの可動接点支持部６３から構成され、可動構造部６０全体が両持ち梁状のねじれ弾性部５３のねじれ弾性により回転可動であると同時に、可動接点支持部６３が両持ち梁状の弾性連絡部６４のねじれ弾性により回転可動構造となる。

【００５２】本実施例に係る静電リレーは、静電アクチュエーターを構成する電極５４，７０間に約２０Ｖ弱の動作電圧を印加することにより、接点５５，７２が閉じ、この時の接点抵抗は約０．２Ωで、接点電流１００ｍＡ以上を流すことが可能であった。この値は小信号用リレーとして、十分実用可能な特性であり、犠牲層となるＳｉＯ₂膜の膜厚を小さくすることや、静電アクチュエーター電極面積の拡大、等の形状寸法変更により、さらに低電圧動作とすることも可能である。

【００５３】比較例として、同様の構造で可動接点支持部を弾性支持する弾性連絡部を持たない従来構造を作成し、評価した結果、同じく動作電圧は約２０Ｖ弱ではあるが、接点抵抗は５～１０Ω以上の高い値を示し、１Ω以下の接点抵抗に下げるためには５０Ｖ以上の動作電圧が必要であった。更に接点電流を数ｍＡ流したところ、接点が溶着し、オフ動作が不可能になった。

【００５４】以上からも明らかなように、本発明の静電リレー構造を用いれば、従来不可能であった、低電圧駆動、低接点抵抗、高接点容量の実用性の高い静電リレーが容易に構成可能である。

【００５５】なお、本実施例では、薄膜形成技術を用いてリレー構造体となる可動構造部を形成した例を示したが、本発明の静電リレーの構成方法はこれに限るものではなく、例えば可動構造部として単結晶Ｓｉ基板に可動接点と可動電極を形成して、異方性エッチング等の技術を用いて所定の構造に形成後、同じく固定接点と固定電極を形成した絶縁基板上にスペーサーを介して貼り付けても良い。このような場合でも、従来の構造と比較して、容易に低電圧駆動、高接点容量の特性を得ることが可能である。

【００５６】また、リレー構造体となる可動構造部として、表面に絶縁加工をした金属薄板を用いることも可能である。このような方法で形成された静電リレーは、薄膜形成技術を用いた静電リレーと比較して、より大きな接点電流を流す用途に適用可能である。

【００５７】以上本発明の実施の形態及び実施例について説明してきたが、本発明はこれに限定されることなく請求項の記載の範囲内において各種の変形、変更が可能なことは当業者には自明であろう。

【００５８】

【発明の効果】以上説明したように、本発明に係る静電リレーによれば、従来の静電リレーが問題として抱えていた、接点同士の点接触とそれによる接点電流容量不足、接点抵抗上昇等の問題を解決し、接点同士を面接触させることが可能になり、大きな接点容量と低い接点抵抗を達成可能である。

【００５９】更に従来、静電アクチュエーターを構成する電極間の距離が、動作時に十分近接できないために生じていた、接点圧力不十分とそれによる接点抵抗上昇、またこれを克服するために動作電圧が高くなってしまう問題点も、本発明の構成を用いれば、前記電極間距離を従来と比較して著しく接近させることが可能であるため、十分な接点圧力とそれによる低い接点抵抗を、従来より低い動作電圧で達成することが可能になる。

【００６０】これらのリレー特性の著しい改善により、本発明は従来の静電リレーと比較して、極めて実用性が高い静電リレーを構成することが可能である。

【図面の簡単な説明】

【図１】本発明に係る静電リレーの第１の実施の形態を示す平面図である。

【図２】図１のII－II側断面図である。

【図３】第１の実施の形態において接点オン動作途中の状態を示す側断面図である。

【図４】第１の実施の形態において接点オン動作完了状態を示す側断面図である。

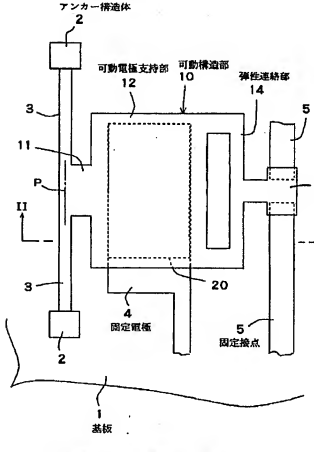
【図５】本発明の第２の実施の形態を示す平面図である。

【図６】図５のVI－VI側断面図である。

【図７】第２の実施の形態において接点オン動作途中の

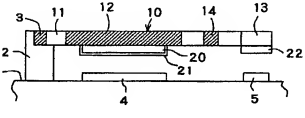
状態を示す側断面図である。
【図８】第２の実施の形態において接点オン動作完了状態を示す側断面図である。
【図９】本発明の第３の実施の形態を示す平面図である。
【図１０】図９のＸ－Ｘ側断面図である。
【図１１】第３の実施の形態において接点オン動作完了状態を示す側断面図である。
【図１２】本発明の第４の実施の形態を示す平面図である。
【図１３】図１２のXIII－XIII側断面図である。
【図１４】第４の実施の形態において一対の静電アクチュエーターの電極間に印加する電圧波形を示す波形図である。
【図１５】第４の実施の形態において切り替えスイッチを構成した場合の回路図である。
【図１６】本発明の実施例を示す平面図である。
【図１７】図１６のXVII－XVII側断面図である。　＊
＊【図１８】本発明の実施例に係る静電リレーの製造過程を示す説明図である。
【符号の説明】
１　基板
２，５２　アンカー構造体
３，５３　両持ち梁状のねじれ弾性部
４，５４　固定電極
５，５５　固定接点
６，２１，５６　絶縁層
１０，１０Ａ，１０Ｂ，３０，４０，６０　可動構造部
１１，４１，６１　両持ち梁接続部
１２，３２，４２，６２　可動電極支持部
１３，３３，４３，６３　可動接点支持部
１４，３４，４４，４５，６４　弾性連絡部
２０，７０　可動電極
２２，７２　可動接点
５１　単結晶Ｓｉ板
８１　犠牲層

【図１】



３：ねじれ弾性部、１３：可動接点支持部

【図２】



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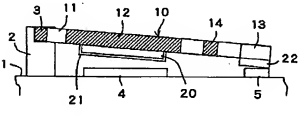

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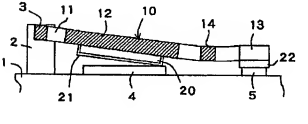

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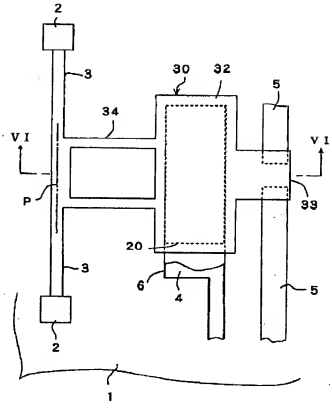

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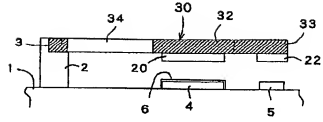

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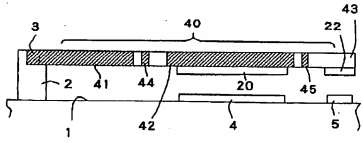

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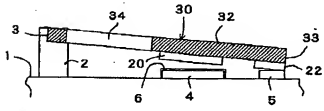

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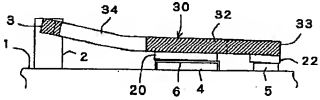

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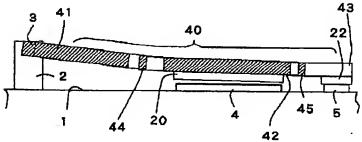

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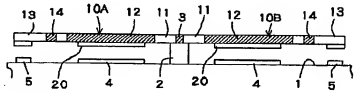

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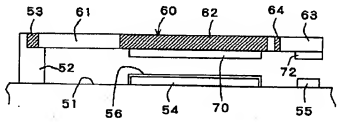

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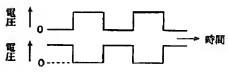

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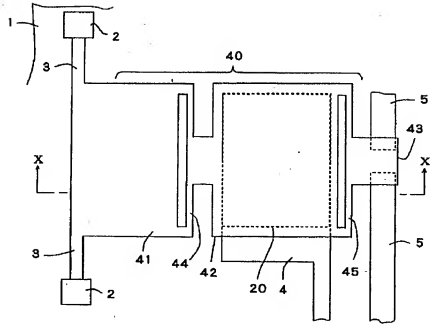
【図９】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4
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5
2

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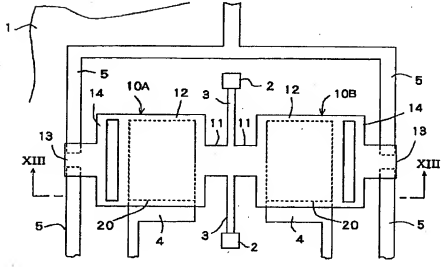
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12
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12
10B
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XIII
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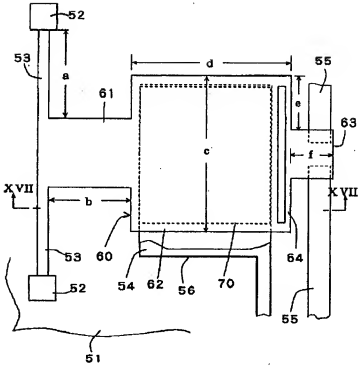
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a
61
d
55
e
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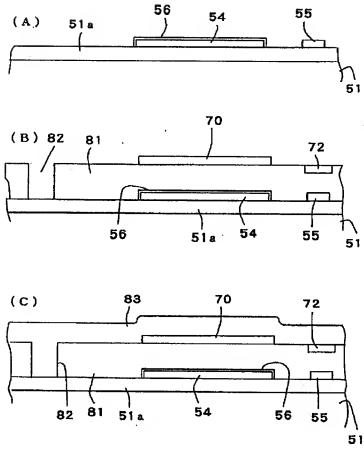
【図１８】


(A)
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51
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81
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72
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51a
54
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51
(C)
83
70
72
82
81
51a
54
56
55
51

PATENT ABSTRACTS OF JAPAN

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(30)Priority
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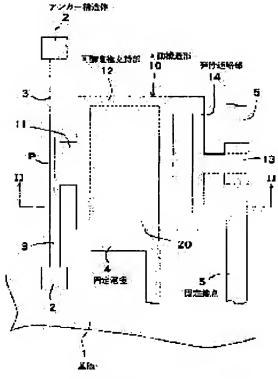
(54) ELECTROSTATIC RELAY

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an electrostatic relay with superior practical applicability of low drive voltage, low contact resistance, and high contact capacity.
SOLUTION: This electrostatic relay comprises a double-supported beam-like twisted elastic part 3 which is held on a substrate 1, while being kept a space from the substrate, a movable structure part 10 made rotatable by the elastic support by the twisted elastic part 3, at least one movable contact arranged in at least one end part of the movable structure part 10, a movable electrode 20 arranged between a rotation fulcrum P of the movable sturcture part 10 and the movable contact, at least one fixed contact 5 formed facing the opposite to the movable contact on the substrate in the manner the movable contact can be brought into contact with the contact 5, and a fixed electrode 4 formed opposite to the movable electrode 20 on the substrate 1. At least a part of the section between the rotation fulcrum P of the movable structure part 10 and the movable contact is an elastic communication part 14.



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of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]
* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] A substrate and the twisting elasticity section of the shape of a doubly-supported beam held with the opening on this substrate, At least one traveling contact arranged at the movable structured division which can rotate freely by the elastic support by this twisting elasticity section, and one [at least] edge of this movable structured division, The movable electrode arranged between the rotation supporting point of said movable structured division, and said traveling contact, In the electrostatic relay equipped with at least one stationary contact formed on said substrate which counters said traveling contact possible [contact], and the fixed electrode formed on said substrate so that said movable electrode might be countered The electrostatic relay characterized by at least the part between the rotation supporting point of said movable structured division and said traveling contact being the elastic Division for Interlibrary Services.
[Claim 2] The electrostatic relay according to claim 1 from which said elastic Division for Interlibrary Services is between said movable electrode in said movable structured division, and said traveling contact, and constituted said traveling contact and said stationary contact from an parallel condition possible [contact] by elastic deformation at the time of electrical-potential-difference impression of a between [said movable electrodes and said fixed electrodes].
[Claim 3] The electrostatic relay according to claim 1 or 2 constituted so that said elastic Division for Interlibrary Services might be between said rotation supporting point in said movable structured division, and said movable electrode and said movable electrode might be attracted by the contiguity condition parallel thru/or near in parallel to said fixed electrode by elastic deformation at the time of electrical-potential-difference impression of a between [said movable electrodes and said fixed electrodes].
[Claim 4] The electrostatic relay according to claim 1, 2, or 3 with which the dielectric layer intervenes between said movable electrodes and said fixed electrodes.
[Claim 5] The electrostatic relay according to claim 1, 2, 3, or 4 with which said fixed electrode is formed on said substrate so that said movable electrode of both sides may be countered, respectively while said movable electrode is arranged for said traveling contact by one [at least] side to said rotation supporting point at both sides, respectively by said movable structured division having extended on both sides of the twisting elasticity section of the shape of said doubly-supported beam.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the electrostatic relay using the electrostatic actuator using electrostatic attraction as a driving source.
[0002]
[Description of the Prior Art] An electrostatic relay is a relay which opens and closes a contact by making electrostatic attraction into driving force unlike the electromagnetic relay using the conventional electromagnet, the coil for generating electromagnetic force is unnecessary, there are few machine parts, in order to use that it can miniaturize and the electrostatic actuator which is essentially a capacitor as a driving source, there is the description of being a low power and research is advanced towards utilization.
[0003] As such an electrostatic relay, as it is in JP,2-100224,A, for example, the seesaw-like structure by which the single crystal Si was connected with the torsion-bar-spring elastic body by selective etching at it is formed, the movable electrode section of an electrostatic actuator and the traveling contact of a relay are formed in the structure, and there are some which have been arranged through a spacer on the electric insulation substrate which prepared the fixed electrode and the stationary contact in the location which counters each.
[0004] By impressing an electrical potential difference between a fixed electrode and a movable electrode at the time of actuation, by torsion of a torsion-bar-spring elastic body, the seesaw-like structure of the side to which the electrical potential difference was impressed rotates, and this electrostatic relay contacts a traveling contact to a stationary contact.
[0005]
[Problem(s) to be Solved by the Invention] In this electrostatic relay, since the traveling contact is prepared in the edge of the seesaw-like structure, in order that a traveling contact may contact in the state of an inclination to a stationary contact at the time of contact, sufficient touch area is not obtained, but contact resistance becomes high. Moreover, since the structure will contact a traveling contact and coincidence if the location of the structure which prepares a traveling contact is not chosen appropriately, the pressure between contacts may become inadequate.
[0006] Furthermore, since the movable electrode which counters a fixed electrode is formed in rotation supporting-point approach rather than the traveling contact location of the seesaw-like structure held through the opening with the torsion-bar-spring elastic body, when a traveling contact contacts a stationary contact and rotation of the seesaw-like structure stops, a wedge-shaped air gap produces such an electrostatic relay of a configuration between a fixed electrode and a movable electrode.
[0007] however, electrostatic attraction -- an electrode spacing -- reverse -- it is proportional to square. Therefore, as for an electrostatic actuator, electrostatic attraction will become small also in the time of suction actuation for this air gap. For this reason, since sufficient pressure for a contact is not applied, in order to be unable to make contact resistance sufficiently small and to conquer this, making operating voltage high will bar the practicality of an electrostatic relay remarkably.
[0008] This invention aims at offering a low-battery drive, low contact resistance, and an electrostatic high relay of the practicality of high contact capacity in view of the above-

mentioned point.
[0009] Other purposes and new descriptions of this invention are clarified in the gestalt of the below-mentioned operation.
[0010]
[Means for Solving the Problem] In order to attain the above-mentioned purpose, an electrostatic relay of this invention A substrate and the twisting elasticity section of the shape of a doubly-supported beam held with the opening on this substrate, At least one traveling contact arranged at the movable structured division which can rotate freely by the elastic support by this twisting elasticity section, and one [at least] edge of this movable structured division, The movable electrode arranged between the rotation supporting point of said movable structured division, and said traveling contact, In the configuration equipped with at least one stationary contact formed on said substrate which counters said traveling contact possible [contact], and the fixed electrode formed on said substrate so that said movable electrode might be countered It is characterized by at least the part between the rotation supporting point of said movable structured division and said traveling contact being the elastic Division for Interlibrary Services.
[0011] Moreover, in said electrostatic relay, it is good for said elastic Division for Interlibrary Services to be between said movable electrode in said movable structured division, and said traveling contact, and to constitute said traveling contact and said stationary contact from an parallel condition possible [contact] by elastic deformation at the time of electrical-potential-difference impression of a between [said movable electrodes and said fixed electrodes].
[0012] Furthermore, it is good to constitute so that said elastic Division for Interlibrary Services may be between said rotation supporting point in said movable structured division, and said movable electrode and said movable electrode may be attracted by the contiguity condition parallel thru/or near in parallel to said fixed electrode by elastic deformation at the time of electrical-potential-difference impression of a between [said movable electrodes and said fixed electrodes].
[0013] In addition, the dielectric layer may intervene between said movable electrodes and said fixed electrodes.
[0014] Moreover, while said movable electrode is arranged for said traveling contact by one [at least] side on both sides to said rotation supporting point, respectively by said movable structured division having extended on both sides of the twisting elasticity section of the shape of said doubly-supported beam, it is good also as a configuration by which said fixed electrode was formed on said substrate so that said movable electrode of both sides might be countered, respectively.
[0015]
[Embodiment of the Invention] Hereafter, the gestalt of implementation of the electrostatic relay concerning this invention is explained according to a drawing.
[0016] Drawing 1 thru/or drawing 4 show the gestalt of implementation of the 1st of the electrostatic relay concerning this invention. Setting to these drawings, the electrostatic relay possesses the twisting elasticity section 3 of the shape of a doubly-supported beam held with the opening from the substrate 1 by the insulating substrate 1, the support structure 2 which was set up and fixed on the substrate 1, and the support structure 2, and the movable structured division 10 which makes the relay structure which can rotate freely by the elastic support by the twisting elasticity section 3. Said insulating substrate 1 is a single crystal Si substrate which insulating processing of the front face is carried out at least, and prepared SiO2 insulating layer in the front face. Three persons of the support structure 2, the doubly-supported beam-like twisting elasticity section 3, and the movable structured division 10 are formed in one with Polycrystal Si etc.
[0017] The movable structured division 10 which constitutes the relay structure consists of the elastic Division for Interlibrary Services 14 which connects the doubly-supported beam connection 11 and the movable electrode supporter 12 linked to the twisting elasticity section 3 of the shape of said doubly-supported beam, the traveling contact supporter 13, and the movable electrode supporter 12 and the traveling contact supporter 13, the elastic Division for

Interlibrary Services 14 is formed in the shape of a doubly-supported beam, and the rotation actuation of the traveling contact supporter 13 is attained by the torsion.
[0018] Like drawing 2 thru/or drawing 4 , the insulating layer (dielectric layer) 21 and traveling contact 22 which covered a movable electrode 20 and this front face, respectively are formed and arranged, and the fixed electrode 4 and the stationary contact 5 are formed and arranged on the substrate which counters these at the substrate opposed face side of the movable structured division 10 as the relay structure. The fixed electrode 4 fixed on the insulating substrate 1 and the movable electrode 20 fixed to the movable electrode supporter 12 are parts which constitute the electrostatic actuator which generates electrostatic attraction with the electrical potential difference impressed among both, and a fixed electrode 4 and a movable electrode 20 are connected to an external power by wiring which is not illustrated.
[0019] Next, the principle of operation of the electrostatic relay shown with the gestalt of the 1st operation is explained. Drawing 2 shows each electrode in non-operating state (condition of not impressing an electrical potential difference), and the location of each contact, and it is open between a contact 5 and 22. If an electrical potential difference is impressed between the fixed electrode 4 which constitutes an electrostatic actuator, and a movable electrode 20, electrostatic attraction occurs between two electrodes, and the movable structured division 10 as the relay structure will be rotated to a substrate side like drawing 3 until a traveling contact 22 contacts a stationary contact 5 according to twisting elasticity deformation of the doubly-supported beam-like twisting elasticity section 3. This rotation supporting point is the location of the line P of drawing 1 .
[0020] With the conventional electrostatic relay, actuation of the relay structure stops at this time. At this time, a traveling contact 22 and a stationary contact 5 are in a point contact condition, sufficient touch area will not be obtained but contact resistance will become high so that clearly from drawing 3 . Moreover, a point of contact is small, and since resistance is high, a passage current concentrates, a contact temperature rise is caused, and it becomes easy to generate failure of joining of a contact etc. Furthermore, since spacing of the fixed electrode 4 and movable electrode 20 of an electrostatic actuator is large again, sufficient electrostatic attraction cannot be generated, and contact pressure cannot be taken enough. This causes the rise of contact resistance. In order to raise contact pressure, a still higher electrical potential difference will have to be impressed, the operating voltage of an electrostatic relay will become high, and practicality will be missing.
[0021] however, in an electrostatic relay of the gestalt of this operation, the elastic Division for Interlibrary Services 14 deforms with the suction force of an electrostatic actuator from this time further -- having -- just -- being alike -- it deforms so that a traveling contact 22 may become parallel to a stationary contact 5, as shown in drawing 4 . Field contact of the contacts 5 and 22 can be carried out in the parallel condition in this time, the stationary contact 5 of a pair can short-circuit by the traveling contact 22 like drawing 1 , and sufficiently low contact resistance and sufficiently big contact current capacity can be obtained so that clearly from drawing 4 . Furthermore, the electrode 4 of an electrostatic actuator and the distance between 20 can be made to approach remarkably as compared with the condition of drawing 3 . That is, since the electrostatic attraction of an electrostatic actuator is inversely proportional to the square of an electrode spacing, it can apply sufficient pressure for a contact as operating voltage is low, and can attain the difficult property in a conventional electrostatic relay called low contact resistance and low operating voltage.
[0022] In addition, if the electrical potential difference between an electrode 4 and 20 is made into zero, as for return and the movable structured division 10, twisting elasticity deformation of the elastic section 3 will return to the original condition at the non-operating state of drawing 2 .

[0023] According to the gestalt of this 1st operation, the effectiveness as follows can be acquired.
[0024] (1) Since the elastic Division for Interlibrary Services 14 was located between the movable electrode 20 in the movable structured division 10 which constitutes the relay structure, and the traveling contact 22 and constituted the stationary contact 5 and the

traveling contact 22 from an parallel condition possible [contact] by torsion elastic deformation at the time of electrical-potential-difference impression of a between [a fixed electrode 4 and a movable electrode 20], it can do field contact of the contacts 5 and 22, and can get sufficiently low contact resistance and sufficiently big contact current capacity.
[0025] (2) The electrode 4 of an electrostatic actuator and the distance between 20 can be made to approach remarkably as compared with the condition of drawing 3 which was a limitation in the case of structure conventionally, can enlarge electrostatic attraction, can apply sufficient pressure for a contact as operating voltage is low, and they can realize the electrostatic relay which can operate with low operating voltage.
[0026] (3) The movable electrode 20 is covered by the insulating layer 21, and electrodes 4 and 20 can prevent certainly the short circuit accident which contacts directly. In addition, even if an insulating layer 21 intervenes between a movable electrode 20 and a fixed electrode 4, an insulating layer 21 is a dielectric with a high dielectric constant compared with air, and does not need to consider the fall of the electrostatic attraction by existence of an insulating layer 21 (it can ignore.).
[0027] In addition, although the gestalt of the 1st operation showed the structure of using the twisting elasticity of a doubly-supported beam, as the elastic Division for Interlibrary Services 14 Do not restrict the configuration of the elastic Division for Interlibrary Services to this, and it is arranged so that said traveling contact and said stationary contact may be contacted in parallel by elastic deformation at the time of electrostatic relay-action electrical-potential-difference impression. The very same effectiveness is acquired in the cantilever configuration pulled out from the movable electrode supporter 12 that what is necessary is just to have the elastic modulus which said both contacts come to contact in parallel with the electrostatic attraction generated between said fixed electrodes and movable electrodes and which can be deformed.
[0028] Drawing 5 thru/or drawing 8 show the gestalt of operation of the 2nd of this invention. In these drawings, the movable structured division 30 which constitutes the relay structure is held by the doubly-supported beam-like twisting elasticity section 3 with a substrate 1 to an opening through the support structure 2 from the insulating substrate 1. The movable structured division 30 consists of the elastic Division for Interlibrary Services 34 which connects the movable electrode supporter 32, the traveling contact supporter 33, and doubly-supported beam-like the twisting elasticity section 3 and the movable electrode supporter 32 by predetermined die length, the elastic Division for Interlibrary Services 34 is formed in band-like [thinner than the movable electrode supporter 32 / two or more], and the change of the movable electrode supporter 32 and the traveling contact supporter 33 of it is attained by the elastic deformation (deformation by bending) to a direction perpendicular to a vertical side.
[0029] Like drawing 6 thru/or drawing 8 , a movable electrode 20 and a traveling contact 22 are formed and arranged, and the insulating layer (dielectric layer) 6 and stationary contact 5 which covered a fixed electrode 4 and this front face are formed and arranged on the substrate which counters these at the substrate opposed face side of the movable structured division 30 as the relay structure, respectively. The fixed electrode 4 fixed on the insulating substrate 1 and the movable electrode 20 fixed to the movable electrode supporter 32 are parts which constitute the electrostatic actuator which generates electrostatic attraction with the electrical potential difference impressed among both.
[0030] In addition, other configurations are the same as that of the gestalt of the 1st operation mentioned above.
[0031] Next, the principle of operation of the electrostatic relay shown with the gestalt of the 2nd operation is explained. Drawing 6 shows each electrode in non-operating state (condition of not impressing an electrical potential difference), and the location of each contact, and it is open between a contact 5 and 22. If an electrical potential difference is impressed between the fixed electrode 4 which constitutes an electrostatic actuator, and a movable electrode 20, electrostatic attraction occurs between two electrodes, and the movable structured division 30 as the relay structure will be rotated to a substrate side like drawing 7 until a traveling contact 22 contacts a stationary contact 5 with the twisting elasticity of the doubly-supported beam-like twisting elasticity section 3.

[0032] In the conventional electrostatic relay, since actuation of the relay structure stops at this time, as explanation of the gestalt of the 1st operation of operation described, troubles, such as lack of a contact touch area, lack of contact pressure, and high operating voltage, arise.
[0033] however, in an electrostatic relay of the gestalt of this operation, the elastic Division for Interlibrary Services 34 which has predetermined die length with the suction force of an electrostatic actuator bends and deforms from this time further -- having -- just -- being alike -- as shown in drawing 8 , it deforms so that a movable electrode 20 and a fixed electrode 4 may be in a condition parallel thru/or near in parallel and a traveling contact 22 and a stationary contact 5 may also be in an parallel condition further. At this time, field contact of the contacts 5 and 22 can be carried out in the parallel condition, and they can obtain sufficiently low contact resistance and big contact current capacity so that clearly from drawing 8 . Furthermore, the electrode 4 of an electrostatic actuator and the distance between 20 can be made to be able to approach as compared with the condition of drawing 7 until they result in contact mostly through an insulating layer 6, and they can generate very strong electrostatic attraction. Therefore, pressure sufficient also with low operating voltage for a contact can be applied, and the difficult property can attain easily in a conventional electrostatic relay called low contact resistance and low operating voltage.
[0034] According to the gestalt of the 2nd operation, it bends. Thus, the deformable elastic Division for Interlibrary Services 34 of predetermined length It is located between the rotation supporting point P in the movable structured division 30 which makes the relay structure (center of twist of the doubly-supported beam-like twisting elasticity section 3), and a movable electrode 20. While it can constitute so that a movable electrode 20 may be attracted by the contiguity condition parallel thru/or near in parallel to a fixed electrode 4 by elastic deformation at the time of electrical-potential-difference impression of a between [a fixed electrode 4 and a movable electrode 20], and being able to enlarge electrostatic attraction Field contact of the contacts 5 and 22 is carried out, it makes it possible to obtain sufficiently low contact resistance and sufficiently big contact current capacity, and an electrostatic relay of further low operating voltage can be realized.
[0035] In addition, although the gestalt of the 2nd operation showed the structure using the elastic deformation to the perpendicular direction to the substrate of a predetermined length part with which the movable structured division 30 was formed thinly as the elastic Division for Interlibrary Services 34 Do not restrict the configuration of the elastic Division for Interlibrary Services to this, and it is arranged so that a movable electrode and a fixed electrode can become parallel by elastic deformation at the time of electrostatic relay-action electrical-potential-difference impression. The same effectiveness is acquired even if it uses torsion rotation of a doubly-supported beam like [that what is necessary is just to have the elastic modulus in which the deformation to which two electrodes result in a condition parallel thru/or near in parallel in the electrostatic attraction generated between said fixed electrodes and movable electrodes is possible] the elastic Division for Interlibrary Services 14 which showed by drawing 1 .
[0036] Drawing 9 thru/or drawing 11 are the gestalten of operation of the 3rd of this invention, and it shows the case where it is prepared also between the rotation supporting point (center of twist of the doubly-supported beam-like twisting elasticity section) of the movable structured division, and a movable electrode while the elastic Division for Interlibrary Services is prepared between the movable electrode in the movable structured division which constitutes the relay structure, and the traveling contact. In these drawings, the movable structured division 40 which constitutes the relay structure is held by the doubly-supported beam-like twisting elasticity section 3 with a substrate 1 to an opening through the support structure 2 from the insulating substrate 1. The movable structured division 40 consists of the 1st elastic Division for Interlibrary Services 44 which connects the doubly-supported beam connection 41 of predetermined length, the movable electrode supporter 42, the traveling contact supporter 43, and the point and the movable electrode supporter 42 of the doubly-supported beam connection 41, and the 2nd elastic Division for Interlibrary Services 45 which connects the movable electrode supporter 42 and the traveling contact supporter 43. The 1st and 2nd elastic Division

for Interlibrary Services 44 and 45 is the doubly-supported beam-like twisting elasticity section, and the movable electrode supporter 42 is supported by the 1st elastic Division for Interlibrary Services 44 to the tip side of the movable electrode supporter 42 free [rotation] to the tip side of the doubly-supported beam connection 41, respectively free [rotation by the 2nd elastic Division for Interlibrary Services 45] for the traveling contact supporter 43.
[0037] In addition, other configurations are the same as that of the gestalt of the 1st operation mentioned above, give the same sign to the same or a considerable part, and omit explanation.
[0038] The situation of the electrostatic relay concerning the gestalt of the 3rd operation to drawing 10 and drawing 11 of operation is shown. Drawing 10 shows each electrode in non-operating state (condition of not impressing an electrical potential difference), and the location of each contact. If an electrical potential difference is impressed between the fixed electrode 4 which constitutes an electrostatic actuator, and a movable electrode 20, electrostatic attraction will occur between two electrodes. Like drawing 11 the movable structured division 40 as the relay structure A traveling contact 22 is contacted to a stationary contact 5 according to twisting elasticity deformation of the doubly-supported beam-like twisting elasticity section 3, and it rotates to a substrate side until it results in the condition of having stuck the traveling contact 22 and the stationary contact 5 in parallel further according to twisting elasticity deformation of the 1st and 2nd elastic Division for Interlibrary Services 44 and 45.
[0039] It becomes possible to make it counter with an air gap, after sticking a traveling contact 22 and a stationary contact 5 in parallel by choosing appropriately the elastic modulus of the 1st [which is the twisting elasticity section], and 2nd elastic Division for Interlibrary Services 44 and 45 when the gestalt of this 3rd operation is taken so that clearly from this drawing 11 , keeping almost parallel the movable electrode 20 and fixed electrode 4 of an electrostatic actuator. While this can obtain electrostatic attraction still stronger than the case where it has a wedge air gap as shown in drawing 3 , it becomes possible to avoid completely contact of a movable electrode 20 and a fixed electrode 4. Therefore, while the insulating layer formed on the movable electrode 20 for constituting an electrostatic actuator or a fixed electrode 4 can make needlessness or withstand voltage low, it becomes possible to avoid problems, such as fixing by actuator inter-electrode unprepared contact.
[0040] Drawing 12 and drawing 13 are the gestalten of operation of the 4th of this invention, extend the relay structure from a substrate on both sides of the twisting elasticity section of the shape of a doubly-supported beam which carries out rotation support of this relay structure, and show the example arranged in the symmetry configuration to the twisting elasticity section of the shape of this doubly-supported beam. That is, the electrostatic relay concerning the gestalt of the 4th operation possesses the movable structured divisions 10A and 10B which make the relay structure by which symmetry arrangement was carried out at both sides so that it can rotate freely by the elastic support by the twisting elasticity section 3 and the twisting elasticity section 3 of the shape of a doubly-supported beam held with the opening from the substrate 1 by the insulating substrate 1, the support structure 2 which was set up and fixed on the substrate 1, and the support structure 2. Since an electrode, a contact arrangement, etc. of each movable structured divisions 10A and 10B are the same as that of the gestalt of the 1st operation mentioned above, they give the same sign to the same or a considerable part, and omit it for details.
[0041] By giving the electrode 4 of the electrostatic actuator of right and left at the time of an electrostatic relay action, and reversal output voltage as shown in drawing 14 among 20, if the configuration of the gestalt of this 4th operation is taken At the time of OFF (OFF) actuation of one relay contact 5 and 22, a pulling-apart operation of the contact concerned is not based only on the return movement by the elasticity of the doubly-supported beam-like twisting elasticity section 3, but it becomes possible to use the electrostatic attraction of an opposite side electrostatic actuator, and off actuation of positive relay contact is attained.
[0042] Moreover, if one pole of a stationary contact on either side is connected to drawing 12 in common like illustration at this time, it is possible to constitute a changeover switch easily, as shown in drawing 15 .
[0043] Furthermore, the group of the stationary contact 5 by the side of the substrate which

counters one traveling contact 22 of the movable structured divisions 10A and 10B and this can be omitted, and it can also consider as the configuration which raised the certainty of OFF actuation.

[0044] In addition, although the gestalt of each operation explained until now showed the example which formed the movable electrode used as one electrode of an electrostatic actuator in the substrate side side of the relay structure (movable structured division) That what is necessary is just to generate electrostatic attraction between a fixed electrode and a movable electrode substantially in addition to this, if it is the insulator and high resistor of a high dielectric constant, the structure, i.e., the relay structure, of an electrostatic actuator, this electrode location If a movable electrode location may be arranged to the opposite side by the side of the substrate side of the relay structure and said structure itself is constituted from a conductive member, it is also possible to use the structure concerned itself as a movable electrode.

[0045] Moreover, two or more traveling contacts 22 arranged at the edge of the relay structure (movable structured division) may be arranged not only in one piece.

[0046]

[Example] Next, an example explains this invention concretely.

[0047] Drawing 16 and drawing 17 are the top views and side elevations of an electrostatic relay which were formed by this example. In this example, the single crystal Si plate 51 which formed with a thickness of about 1 micrometer SiO2 insulating-layer 51a by the oxidizing [thermally] method like drawing 18 (A) first was used as the substrate, Au with a thickness of about 500nm was formed all over the substrate by the spatter, then photo etching was used, and patterning of the fixed electrode 54 of an electrostatic actuator and the stationary contact 55 of a relay was carried out, respectively. Next, by the reactant spatter, about 100nm SiN insulating layer was formed all over the substrate, similarly it left the fixed electrode 54 top of an electrostatic actuator by the photo etching method, selection removal of this insulating layer was carried out, and it considered as the insulating layer 56.

[0048] Next, about 3 micrometers of SiO2 film which serves as the sacrifice layer 81 all over a substrate were deposited using the reduced pressure CVD method like drawing 18 (B). And about 500nm of SiO2 film of the location equivalent to a traveling contact 72 was investigated by the RIE method, about 500nm Au film was further formed with about 20nm SiN reaction prevention layer all over the substrate, patterning was carried out to the predetermined configuration by photo etching, and the movable electrode 70 of an electrostatic actuator and the traveling contact 72 of a relay were formed. Furthermore, selection removal of the part 82 equivalent to the support structure 52 of SiO2 film of the sacrifice layer 81 is carried out after this using photo etching.

[0049] Finally the reduced pressure CVD method was used, about 4 micrometers of polycrystal Si film 83 were formed all over the substrate like drawing 18 (C), and patterning was carried out to the configuration of the movable structured division used as the relay structure described below by the RIE method.

[0050] Then, selective etching of the SiO2 film of the sacrifice layer 81 was carried out by HF, and the movable structured division 60 used as the relay structure shown in drawing 16 and drawing 17 was released and formed.

[0051] Die-length a from the support structure 52 of the doubly-supported beam-like twisting elasticity section 53 is about 100 micrometers and about 6 micrometers of ****. Moreover, the movable structured division 60 which constitutes the relay structure The movable electrode supporter 62, 6 micrometers of **** whose doubly-supported beam connection 61, width of face c, and die-length d whose die-length b is about 100 micrometers are about 200 micrometers, respectively, It consists of the doubly-supported beam-like twisting elasticity Division for Interlibrary Services 64 whose die-length e is about 50 micrometers, and a traveling contact supporter 63 whose die-length f is about 50 micrometers. the movable structured division 60 whole -- the twisting elasticity of the doubly-supported beam-like twisting elasticity section 53 -- rotation -- while it is movable, the traveling contact supporter 63 serves as rotation movable structure with the twisting elasticity of the elastic doubly-supported beam-like Division for

Interlibrary Services 64.
[0052] Contacts 55 and 72 closed the electrostatic relay concerning this example by impressing the operating voltage of about 20 a little less thanv between the electrode 54 which constitutes an electrostatic actuator, and 70, the contact resistance at this time was about 0.2ohms, and it was possible to have passed 100mA or more of contact currents. This value is a sufficiently usable property as a relay for small signals, and it is also possible to consider as low-battery actuation further by geometry modification of to make small thickness of SiO2 film used as a sacrifice layer, expansion of an electrostatic actuator electrode surface product, etc.
[0053] As a result of the same structure's creating and estimating structure as an example of a comparison conventionally without the elastic Division for Interlibrary Services which does elastic support of the traveling contact supporter, similarly operating voltage was about 20 a little less thanv, but in order to show the high value of 5-10ohms or more and to lower to contact resistance 1ohm or less, the operating voltage beyond 50V was required for contact resistance. Furthermore, when the several mA contact current was passed, the contact welded and off actuation became impossible.
[0054] If the electrostatic relay structure of this invention is used so that clearly also from the above, the conventionally impossible low-battery drive, low contact resistance, and an electrostatic high relay of the practicality of high contact capacity can constitute easily.
[0055] In addition, you may stick through a spacer on the insulating substrate which does not restrict the configuration approach of an electrostatic relay of this invention to this although the example in which the movable structured division which serves as the relay structure, using thin film coating technology at this example was formed is shown, formed the traveling contact and the movable electrode in the single crystal Si substrate as the movable structured division, for example, similarly formed the stationary contact and the fixed electrode using techniques, such as anisotropic etching, after forming in predetermined structure. Even in such a case, as compared with the conventional structure, it is possible to acquire a low-battery drive and the property of high contact capacity easily.
[0056] Moreover, it is also possible to use for a front face the metallic thin plate which carried out insulating processing as the movable structured division used as the relay structure. The electrostatic relay formed by such approach is applicable to the application which passes a bigger contact current as compared with the electrostatic relay which used thin film coating technology.
[0057] Although the gestalt and example of operation of this invention have been explained above, probably, as for this invention, it will be obvious to this contractor for various kinds of deformation and modification to be possible within the limits of the publication of a claim, without being limited to this.
[0058]
[Effect of the Invention] As explained above, according to the electrostatic relay concerning this invention, the conventional electrostatic relay can solve problems, such as lack of contact current capacity by the point contact of contacts and it which were being held as a problem, and a contact resistance rise, it can become possible to carry out field contact of the contacts, and big contact capacity and low contact resistance can be attained.
[0059] Furthermore, if the configuration of this invention is used, since it is possible to make said inter-electrode distance approach remarkably as compared with the former also as for the trouble that operating voltage becomes high in order to conquer conventionally the contact-resistance rise which it had produced since an inter-electrode distance which constitutes an electrostatic actuator was not able to approach enough at the time of actuation according being inadequate in contact pressure to it, and this, it becomes possible to attain the low contact resistance by sufficient contact pressure and sufficient it with operating voltage lower than before.
[0060] It is possible for this invention to constitute the electrostatic relay with very high practicality by remarkable improvement of these relay properties as compared with the conventional electrostatic relay.

[Translation done.]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the top view showing the gestalt of implementation of the 1st of the electrostatic relay concerning this invention.
[Drawing 2] It is the II-II sectional side elevation of drawing 1 .
[Drawing 3] It is the sectional side elevation showing the condition in the middle of contact ON actuation in the gestalt of the 1st operation.
[Drawing 4] It is the sectional side elevation showing the completion condition of contact ON actuation in the gestalt of the 1st operation.
[Drawing 5] It is the top view showing the gestalt of operation of the 2nd of this invention.
[Drawing 6] It is the VI-VI sectional side elevation of drawing 5 .
[Drawing 7] It is the sectional side elevation showing the condition in the middle of contact ON actuation in the gestalt of the 2nd operation..
[Drawing 8] It is the sectional side elevation showing the completion condition of contact ON actuation in the gestalt of the 2nd operation.
[Drawing 9] It is the top view showing the gestalt of operation of the 3rd of this invention.
[Drawing 10] It is the X-X sectional side elevation of drawing 9 .
[Drawing 11] It is the sectional side elevation showing the completion condition of contact ON actuation in the gestalt of the 3rd operation.
[Drawing 12] It is the top view showing the gestalt of operation of the 4th of this invention.
[Drawing 13] It is the XIII-XIII sectional side elevation of drawing 12 .
[Drawing 14] It is the wave form chart showing the voltage waveform impressed to inter-electrode [of the electrostatic actuator of a pair] in the gestalt of the 4th operation.
[Drawing 15] It is a circuit diagram at the time of constituting a changeover switch in the gestalt of the 4th operation.
[Drawing 16] It is the top view showing the example of this invention.
[Drawing 17] It is the XVII-XVII sectional side elevation of drawing 16 .
[Drawing 18] It is the explanatory view showing the manufacture process of the electrostatic relay concerning the example of this invention.
[Description of Notations]
1 Substrate
2 52 Support structure
3 53 The doubly-supported beam-like twisting elasticity section
4 54 Fixed electrode
5 55 Stationary contact
6, 21, 56 Insulating layer
10, 10A, 10B, 30, 40, 60 Movable structured division
11, 41, 61 Doubly-supported beam connection
12, 32, 42, 62 Movable electrode supporter

13, 33, 43, 63 Traveling contact supporter
14, 34, 44, 45, 64 Elastic Division for Interlibrary Services
20 70 Movable electrode
22 72 Traveling contact
51 Single Crystal Si Plate 81
 Sacrifice Layer

[Translation done.]

* NOTICES *

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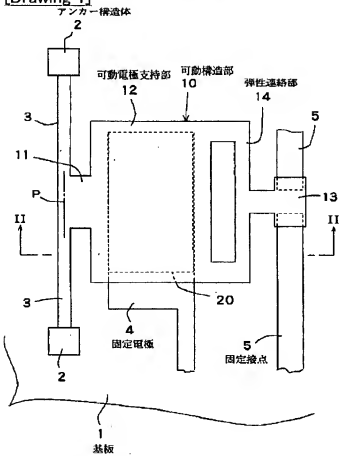
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

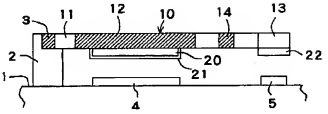
DRAWINGS

[Drawing 1]

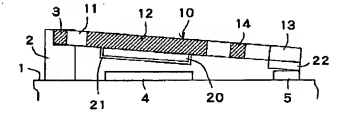


3：ねじれ弾性部、１３：可動接点支持部

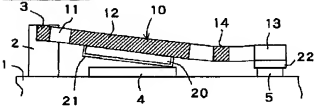
[Drawing 2]



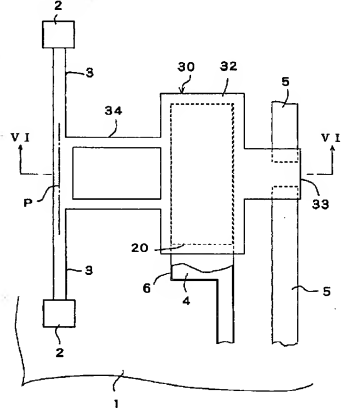
[Drawing 3]



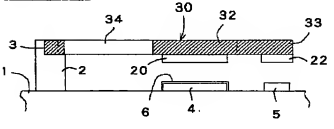
[Drawing 4]



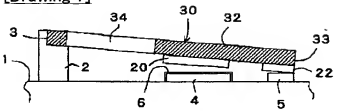
[Drawing 5]



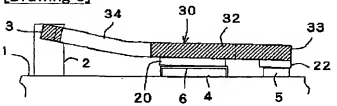
[Drawing 6]



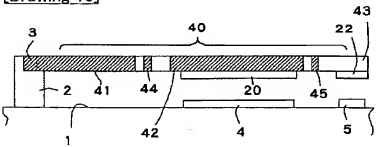
[Drawing 7]



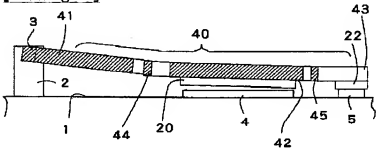
[Drawing 8]



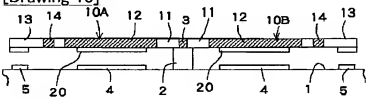
[Drawing 10]



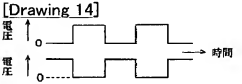
[Drawing 11]



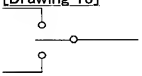
[Drawing 13]



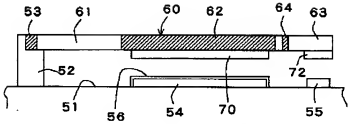
[Drawing 14]



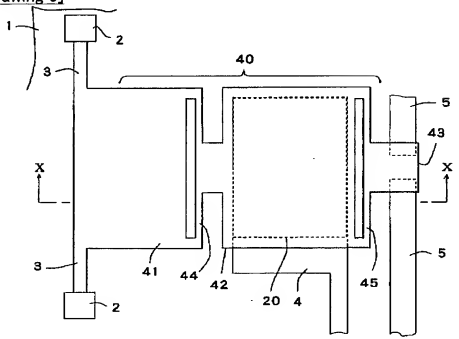
[Drawing 15]



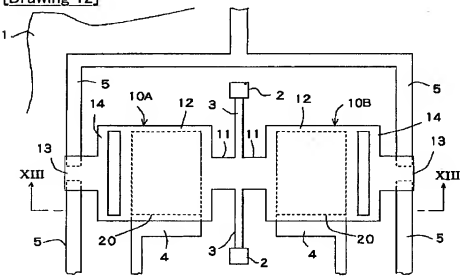
[Drawing 17]



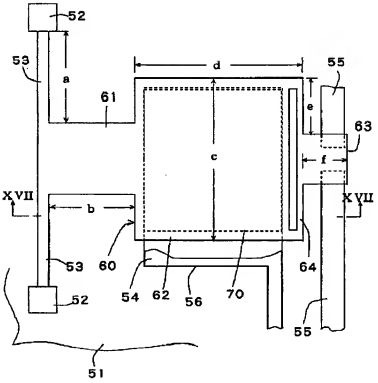
[Drawing 9]



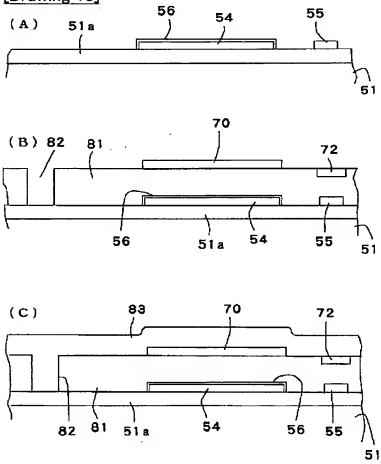
[Drawing 12]



[Drawing 16]



[Drawing 18]



[Translation done.]